

Associations of Sarcopenia Components With Physical Activity and Nutrition in Australian Older Adults Performing Exercise Training

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Abstract

Background: The risk of progressive declines in skeletal muscle mass and strength, termed sarcopenia, increases with age, physical inactivity and poor diet. The purpose of this study was to explore associations of sarcopenia components with self-reported physical activity and nutrition in older adults participating in resistance training at conventional or Helsinki University Research [HUR] gyms.

Methods: Muscle strength (via handgrip strength and chair stands), appendicular lean mass [ALM] (via dual energy X-ray absorptiometry) and physical performance (via gait speed over a 4-metre distance, short physical performance battery, timed up and go and 400-metre walk tests) were evaluated in a cohort study of 80 community-dwelling older adults (mean±SD 76.5B6.5 years). Pearson correlations explored associations for sarcopenia components with self-reported physical activity (via Physical Activity Scale for Elderly [PASE]) and nutrition (via Australian Eating Survey), with higher scores indicative of greater physical activity levels and better nutrition, respectively.

Results: No differences in PASE were observed between HUR and conventional gyms, however HUR gym participants had a significantly higher self-reported protein intake and a trend ($p = 0.055$) to have higher energy intake. In both gym groups, gait speed was positively associated with self-reported physical activity ($r = 0.275$; $p = 0.039$ and $r = 0.423$; $p = 0.044$ for HUR and conventional gyms, respectively). ALM was positively associated with protein ($p = 0.047$, $r = 0.418$) and energy ($p = 0.038$, $r = 0.435$) intake in the conventional gym group. Similar associations were observed for ALM/h² in the HUR group. None of the sarcopenia components were associated with the Australian Recommended Food Score (derived from the Australian Eating Survey) in either gym group.

Background

The risk of progressive decline in skeletal muscle mass and strength, termed sarcopenia, increases with age, chronic disease, physical inactivity and poor diet [1–3]. Nutrition is an important part of muscle mass and function [4–6]. Since muscle function is affected by poor nutrition, hand grip strength (HGS) has become a marker of nutritional status [7–9] and an outcome predictor for nutritional interventions [9]. HGS is a key component of major sarcopenia definitions (the Foundation for the National Institutes of Health Sarcopenia Project and European Working Group on Sarcopenia in Older People) and has also been correlated with a number of performance measures, including the timed up and go (TUG) test [10]. The TUG predicts changes in functional balance [11] and its abnormal results are associated with future cardiovascular mortality in women, people without obesity, without diabetes or non-smoking older adults [12].

Further, the short physical performance battery (SPPB) shows acceptable value for diagnosis of older adults with severe sarcopenia and its high sensitivity at the cut-point of ≤ 8 suggests it may be a useful sarcopenia screening tool in the clinical setting in the absence of ALM measurements [13]. SPPB scores ≤ 6 are associated with a higher rate of falls [14] and ≤ 10 with decreased mobility [15]. Patients with a poor SPSS score (0–4) at hospital discharge have a higher risk of re-hospitalisation [16]. An SPPB score below 10 is predictive of all-cause mortality [17, 18]. The 400-metre (400mw) test predicts cardiovascular disease, mobility limitation and disability [19], and mortality [19, 20].

Low protein and energy intakes are linked to sarcopenia [5, 21] and benefits of appropriate nutrition have been reported alone and in conjunction with resistance training [22, 23]. Although the provision of exercise programs in aged-care centres is not uncommon [24–26], there is a lack of data on the relationship between sarcopenia components (muscle strength, lean mass and physical performance) and physical activity levels and nutritional status amongst participants using Helsinki University Research (HUR) and conventional gym equipment.

Our aim was to examine associations of sarcopenia components with self-reported physical activity and nutrition in older adults performing exercise training at four gyms owned and operated by an aged care provider. We hypothesized that self-reported physical activity and nutrition contribute to improvements in muscle mass and function. Further, there is no difference in the type of gym being used (HUR or conventional gym training).

Methods

We applied a cross-sectional design using convenience sampling to observe participants that were undergoing training exercises under supervision of exercise physiologists and physiotherapists at four gyms of Uniting AgeWell in Melbourne, Australia.

Participants

All gym clients of Uniting AgeWell who were accepted to take part in the exercise training were eligible to participate. Three sites, Forest Hill, Noble Park (both attached to the residential care) and Oakleigh gyms used Helsinki University Research (HUR) equipment, while the fourth site in Hawthorn used the conventional equipment. Training duration was generally one hour, and the frequency varied depending on individual programs (usually once or twice per week), with programs ranging 2–3 sets with 8–20 repetitions. Data from 80 community-dwelling older adults, who had already been undergoing resistance training, was collected in March-May 2019. Study profile and measures are detailed elsewhere (manuscript under review BGTC-D-20-00772).

Sarcopenia components

Appendicular lean mass (ALM). Dual-energy X-ray absorptiometry (DXA) (Hologic Horizon A, MeasureUp, Melbourne) was used to measure weight, ALM (kg), which is defined as the sum of lean soft-tissue mass from both the arms and legs [27] and a stadiometer (Charder HM200P, Charder Electronic Co. Ltd, Tachung City, Taiwan) to measure height. Absolute and normalised parameters were reported, as age-related changes in lean mass and body size may affect loss of muscle mass with age [28].

Hand grip strength (HGS). HGS (kg) was tested with subjects seated upright, with elbow bent 90° and forearm resting on an armrest support, using a handgrip dynamometer (Jamar Plus+, SI Instruments, Adelaide, Australia). Following a practice test, two trials were recorded for each hand with the subject squeezing as hard as possible and the highest score of all six tests was used for analysis [29].

Short Physical Performance Battery (SPPB). Lower extremity function was assessed using SPPB, consisting of balance with different stances, gait speed (GS) timed over a 4-metres course at normal speed, and a five-chair stand (CS) test. Time was recorded using a sports stopwatch (cat. no. XC027, Jaycar, Melbourne, Australia).

Timed up and go (TUG). Mobility, balance and agility were tested via the TUG (s) test at normal speed, which consisted of rising from seated position, walking three metres to a cone, turning around it, walking back and sitting down on the chair again. Participants walked at normal speed and the chair was positioned with back against a wall for safety. Following an initial trial, two further attempts were recorded and the shortest times was reported in the study [30].

400-metre walk (400mW). Mobility and cardiovascular fitness were assessed with a 400mW (min) test. The standard course is 20 metres with participants walking up around a cone and back 10 times as fast as possible. Due to constraints of available space, the course was 10 metres long walked 20 times. Only one attempt at this test was allowed at the end of the testing day.

Self-reported physical activity status

Physical activity status over the past week (not including any gym sessions) was assessed via a 12-item Physical Activity Scale for the Elderly (PASE) questionnaire, including activities such as walking and light, moderate or strenuous sport over the previous week [31]. Total PASE scores were calculated by multiplying the amount of time spent on each activity by respective weights and adding up all activities, usually ranging between 0 and 360, with higher scores signifying higher physical activity levels [31].

Self-reported nutritional status

Participants were also asked to complete the Australian Eating Survey (AES) for adults, providing a comparison of food and nutritional intake with nutrition targets in the past 3–6 months. In this study, we analysed protein and energy intake and the Australian Recommended Food Score (ARFS) derived from the AES. The ARFS has been validated for children [32–34] and adults [34]; however, this is its first use in a potentially sarcopenic population. The ARFS is a summary score of the overall healthiness and nutritional quality of usual eating patterns. According to the report provided 'Guidance on Food and Nutrition Intake Output' (2016, v.1.0), the total ARFS is 73 points, which is made up of vegetables (21), fruit (12), protein foods: meat/flesh (7), protein foods: meat/flesh alternatives (6), grains, breads, cereals (13), dairy (11), water (1), and extras (2). A score < 33 points indicates 'needs work', 33–38 'getting there', 39–46 'excellent', and 47 and over 'outstanding'. Thus, a higher ARFS score means healthier eating patterns and dietary intake that is of higher nutritional quality.

Statistical analysis

Data is expressed as mean (SD) or frequency (%) unless otherwise specified. Descriptive statistics were performed on continuous variables and frequency analyses on nominal variables. Continuous data was assessed for normality and parametric tests were used as appropriate. Pearson correlations examined associations for sarcopenia components (muscle strength, lean mass and physical performance) with self-reported physical activity and nutritional status. The Pearson coefficient was interpreted as weak (0.1–0.3), moderate (0.3–0.7) and strong (0.7–1.0). Independent-sample t-tests (continuous data) were used to compare self-reported physical activity and nutrition between HUR and conventional gyms. A p-value < 0.05 at 95% confidence intervals was considered statistically significant. All analyses were performed using IBM SPSS Statistics for Mac, version 25 (IBM Corp., Armonk, NY, USA).

Results

Baseline characteristics

Baseline characteristics of the whole cohort are shown in Table 1. Three-quarters of the cohort were of English/Australian ethnicity. Participants had been training for a little over a year, once a week on average. The SPPB score showed subjects were a high functioning group. However, the PASE score was overall low and the AES indicated the average was "getting there".

Table 1
Baseline characteristics (n = 80)

Demographics	Age (yr), mean (ST)	76.53 (6.45)
	Women (%)	66
	English/Australians (%)	76
Training	HUR (%)	71
	Years trained	1.26 (0.64)
	Weekly gym visits	1.05 (0.50)
Anthropometric measurements	Height (cm)	163.67 (9.42)
	Weight (kg)	75.34 (17.34)
	BMI (kg/m ²)	28.02 (5.53)
DXA	Total lean mass (kg)	47.07 (10.94)
	Total fat mass (kg)	26.18 (10.21)
	Total fat (%)	34.25 (8.15)
	Total BMC (kg/cm ²)	2.09 (0.49)
Lean mass	ALM (kg)	19.05 (5.19)
FNIH	ALM/ _{BMI} (kg/m ²)	0.69 (0.16)
EWGSOP1/EWGSOP2	ALM/h ² (kg/m ²)	7.01 (1.34)
Muscle strength	HGS (kg)	26.23 (8.30)
	CS (s)	9.67 (3.84)
Physical performance	GS (m/s)	1.32 (0.24)
	SPPB (score) median (IQR)	12.00 (1)
	TUG (s)	8.52 (4.00)
	400 mW (min)	5.51 (1.64)
Physical activity	PASE (score)	127.30 (56.76)
Nutrition	AES-ARFS (total score)	35.74 (9.22)
	AES daily protein (g)	102.43 (37.14)
	AES daily energy (kJ)	9,286.35 (3,029.77)

All data are mean (SD) or frequency (%). HUR: Helsinki University Research, BMI: body mass index; BMC: bone mineral content; HGS: hand grip strength; CS: chair stand; ALM: appendicular lean mass; HGS: hand grip strength, GS: gait speed; SPPB: short physical performance battery; TUG: timed up and go test; 400mW: 400-metre walk test; FNIH: Foundation for the National Institutes of Health Sarcopenia Project; EWGSOP: European Working Group on Sarcopenia in Older People; PASE: Physical Activity Scale for the Elderly; AES: Australian Eating Survey; ARFS: Australian Recommended Food Score (obtained from the AES).

Comparison of self-reported physical activity and nutrition between HUR and conventional gym training

There was no significant difference in PASE and ARFS scores between the gym groups. However, HUR gym participants had a significantly higher protein intake ($p = 0.029$) than the conventional gym participants. Additionally, the HUR group tended ($p = 0.055$) to have higher self-reported energy intake than the conventional group.

Table 2

Comparison of sarcopenia components and self-reported physical activity and nutrition between HUR and conventional gym training ($n = 80$)

Component	HUR ($n = 57$)	Conventional ($n = 23$)	P-value for difference
PASE (score)	127.02 (61.44)	127.98 (44.28)	0.946
ARFS (total score), mean (SD)	35.72 (9.72)	35.78 (8.05)	0.978
AES protein (g), mean (SD)	108.15 (39.25)	88.25 (27.17)	0.029 *
AES energy (kJ), mean (SD)	9,697.93 (3,006.10)	8,266.35 (2,904.09)	0.055
HUR: Helsinki University Research; PASE: Physical Activity Scale for the Elderly; ARFS: Australian Recommended Food Score; AES: Australian Eating Survey. All analyses are independent-sample t-tests; * $p < 0.05$			

Associations of sarcopenia components with self-reported physical activity and nutritional status

For HUR gym participants, Pearson associations showed that GS had a significant weak, positive relationship with PASE ($p = 0.039$), indicating that a higher GS (better function) was associated with a higher PASE score (greater self-reported physical activity levels) (Table 2). ALM had no significant correlations, however ALM/h² had a significant weak, positive association with protein intake ($p = 0.028$) and moderate, positive association with energy intake ($p = 0.006$), indicating that higher ALM/h² was associated with a greater self-reported protein/energy intake. No other significant associations were observed in HUR gym participants.

Table 3

Associations of self-reported sarcopenia risk, physical activity, HRQoL and nutrition with sarcopenia components at baseline for HUR gym participants (n = 57)

		Muscle strength		Lean mass			Physical performance			
Component		HGS (kg)	CS (s)	ALM (kg)	ALM/ _{BMI} (kg/m ²)	ALM/h ² (kg/m ²)	GS (m/s)	SPPB (score)	TUG (s)	400 mW (min)
PASE (score)	Pearson Coefficient	0.220	0.078	-0.005	-0.203	0.153	0.275*	0.210	-0.239	-0.077
	p	0.101	0.565	0.968	0.131	0.257	0.039	0.117	0.073	0.567
AES-ARFS (total score)	Pearson Coefficient	-0.190	-0.025	0.097	-0.142	0.230	-0.096	-0.183	0.178	-0.067
	p	0.156	0.854	0.475	0.292	0.085	0.475	0.173	0.184	0.618
AES protein (g)	Pearson Coefficient	0.004	-0.044	0.131	-0.168	0.291*	0.216	0.047	-0.012	-0.109
	p	0.977	0.743	0.330	0.213	0.028	0.107	0.729	0.929	0.420
AES energy (kJ)	Pearson Coefficient	0.046	-0.067	0.132	-0.255	0.358**	0.085	-0.063	0.071	-0.071
	p	0.734	0.621	0.329	0.055	0.006	0.531	0.644	0.598	0.599
HRQoL: health-related quality of life; HUR: Helsinki University Research; HGS: hand grip strength; CS: chair stand; ALM: appendicular lean mass; BMI: body mass index; SPPB: short physical performance battery; TUG: timed up and go test; 400-metre walk test; PASE: Physical Activity Scale for the Elderly; AES: Australian Eating Survey; ARFS: Australian Recommended Food Score. All analyses are Pearson correlations; ** p < 0.01, * p < 0.05										

For conventional gym participants, GS also had a significant moderate, positive correlation with PASE ($p = 0.044$) (Table 4). 400 mW had a significant moderate negative relationship with PASE ($p = 0.021$), implying that a lower 400 mW time (faster walking speed) was associated with a higher PASE score (greater physical activity levels). ALM had a significant moderate, positive correlation with self-reported protein ($p = 0.047$) and energy ($p = 0.038$) intake, indicating that low lean mass is associated with low protein/energy intake. When ALM was normalised for height squared, it maintained its significant moderate, positive relationship with protein ($p = 0.043$) and energy ($p = 0.020$) intake. Consistent with HUR gym participants, there was no significant association when ALM was corrected for BMI in conventional gym participants (see Table 3 and Table 4, respectively).

At both HUR and conventional gyms, no significant relationship was observed either for muscle strength or lean mass measures with PASE, or muscle strength and physical performance with protein/energy intake. ARFS was not associated with any of the sarcopenia components.

Table 4

Associations of self-reported physical activity and nutrition with sarcopenia components at baseline for conventional gym participants (n = 23)

		Muscle strength		Lean mass			Physical performance			
Component		HGS (kg)	CS (s)	ALM (kg)	ALM/BMI (kg/m ²)	ALM/h ² (kg/m ²)	GS (m/s)	SPPB (score)	TUG (s)	400 mW (min)
PASE (score)	Pearson Coefficient	0.396	-0.283	0.171	-0.034	0.226	0.423*	0.240	-0.351	-0.479*
	p	0.061	0.190	0.435	0.879	0.301	0.044	0.270	0.101	0.021
AES-ARFS (total score)	Pearson Coefficient	-0.011	-0.097	0.007	-0.018	0.003	0.060	0.144	-0.190	-0.144
	p	0.959	0.660	0.973	0.934	0.989	0.786	0.512	0.386	0.512
AES protein (g)	Pearson Coefficient	0.259	0.090	0.418*	0.093	0.425*	-0.169	-0.077	0.088	0.048
	p	0.232	0.683	0.047	0.673	0.043	0.440	0.727	0.689	0.827
AES energy (kJ)	Pearson Coefficient	0.134	0.119	0.435*	0.013	0.482*	-0.169	-0.068	0.104	0.091
	p	0.542	0.588	0.038	0.955	0.020	0.440	0.756	0.637	0.679

HRQoL: health-related quality of life; HGS: hand grip strength; CS: chair stand; ALM: appendicular lean mass; BMI: body mass index; SPPB: short physical performance battery; TUG: timed up and go test; 400-mW walk test; PASE: Physical Activity Scale for the Elderly; AES: Australian Eating Survey; ARFS: Australian Recommended Food Score. All analyses are Pearson correlations; ** p < 0.01, * p < 0.05

Discussion

In this study, only GS (but not muscle strength) at both HUR and conventional gyms was positively associated with PASE scores, indicating higher self-reported activity is associated with better gait speed. This is similar to previous reports of PASE scores being positively correlated with GS [31]. Given GS is linked with health and longevity [35], it underlines the importance of maintaining physical activity additional to any gym sessions. Our results are inconsistent with evidence that low PASE scores, indicative of low physical activity, are related to muscle strength in older adults [36], as we did not find any association between muscle strength and PASE. It is likely that associations with strength could be masked due to participants already taking part in resistance exercise training programs designed to improve muscle strength.

Rizzoli et al. (2013) report that associations between self-reported and performance-based measures range from small to medium, with GS and CS among the most responsive performance-based measures [37]. The 400 mW test was introduced within the EWGSOP₂ definition to test mobility and endurance [38]. Only in the HUR gym group, 400 mW was negatively correlated with PASE, indicating that higher levels of physical activity are associated with faster walking speeds and better endurance. Taken with the above, PASE appears to be a useful survey tool for evaluating lower leg mobility/speed, and GS and 400 mW continue to be positively influenced by physical activity additional to concurrent resistance training.

PASE scores can range between 0 and 360 in older populations [31]. In our whole sample, the mean score of ~ 127 was higher than reported for US (103) [31], Malaysian (95) [39] or Turkish community-dwelling older adults (M: 122) [40]. However, our participants are not only community-dwelling, but have been undertaking resistance training for over a year on average. Thus, the relatively low PASE score of our Melbourne cohort may indicate that participants substitute general activity with their supervised gym time. Those who attend gyms should be encouraged to not view it as their only form of exercise, but ensure it is in addition to their regular physical activity. A recent study asked 103 Australians aged 50–92 years about sustainable lifestyles [41]. Thirty percent regarded exercise as a priority; of which 11% mentioned irregular activities (e.g., gardening and walking), another 11% purposeful exercise (e.g., gym and water aerobics) and 8% regular exercise (e.g., golf and tennis) [41]. Boulton-Lewis et al. (2019) argue that lack of awareness of exercise benefits and barriers are not new, emphasising the importance of measuring motivation and engagement to develop strategies to enhance physical activity. Group exercise classes are showed to offer social support and enhance exercise training and adherence [42].

Studies show that low protein and energy intake is linked with sarcopenia [5, 21]. There is also a strong correlation between lean mass and nutritional status in older populations [43]. In the present study, the HUR group had significantly higher self-reported protein intake and approached significance ($p = 0.055$) to have higher energy intake. This may be related to the fact that they also tended to have higher BMI ($p = 0.055$) than the conventional gym participants. Lower ALM/h² was significantly associated with lower self-reported protein and energy intake in both gym groups, supporting that sufficient energy intake, and protein specifically, is essential for skeletal muscle maintenance. Interestingly, our results do not show any correlations for self-reported protein/energy intake with HGS. This is inconsistent with prior research showing that since muscle function is affected by poor nutrition, HGS has become a marker of nutritional status [7–9] and an outcome predictor for nutritional interventions [9]. Again, given our participants are specifically training for strength, this may have masked any effect of poor nutrition or lower protein intakes.

None of the sarcopenia components were associated with the ARFS total score. However, based on a total score of 73 for the ARFS [34], our mean results of ~ 36 for both gym groups indicate that participants are not achieving the right nutritional balance in their food intake. It is possible that participants are not obtaining as great a benefit from engaging in exercise as they could be if they were to meet protein intake guidelines. It is very well established, at least in younger individuals, that ingesting high-quality protein with training augments the beneficial effects [44–46]. However, older individuals require higher amounts of protein to increase protein synthesis at the same levels as a younger individual [47–49], and the recommended dietary intake (RDI) is based on not becoming deficient, rather than being an optimal dose. A recent meta-analysis reports that muscle mass increase required protein intakes of up to 1.6 g/kg/day and was more effective in resistance-trained people but less effective in people over 60 years [49]. As most participants in this study had engaged in resistance training for some time, it is likely that insufficient protein was being ingested. Thus, guidance on improving protein intake and protein/energy ratio should be provided to improve lean mass. health.

Given the above, education on nutrition and regular physical activity, in addition to existing gym-based exercises, should be promoted at both gyms. Practitioners could use strategies incorporating exercises (particularly resistance training) and appropriate nutritional advice to prevent loss of muscle mass and muscle strength. There are some limitations in our study including unbalanced groups between HUR and conventional gyms due to the cross-sectional design and convenience sampling. The 400 mW test had to be modified to a 10-metre course walked 20 times rather than the standard 20 metres walked 10 times back and forth given available space in the gyms. In addition, results of this study may not be generalised to the general population as subjects were limited to older exercising adults in Melbourne, Australia.

Conclusion

Low GS was associated with inadequate physical activity and low lean mass with inadequate nutrition and low protein ingestion, even in older adults participating in resistance exercise training programs. Ensuring maintenance of adequate nutrition and non-supervised physical activity is essential for maintaining skeletal muscle mass and function and may enhance the benefits of supervised training for older adults.

Abbreviations

AES: Australian Eating Survey; ALM: Appendicular lean mass; ARFS: Australian Recommended Food Score; BMC: Bone mineral content; BMI: Body mass index; DXA: Dual-energy X-ray absorptiometry; EWGSOP: European Working Group on Sarcopenia in Older People; GS: Gait speed; HGS: Hand grip strength; CS: chair stand; PASE: Physical Activity Scale for the Elderly; RDI: Recommended Dietary Intake; SPPB: Short physical performance battery; TUG: Timed up and go test; 400mW: 400-metre walk

Declarations

Ethics approval and consent to participate

Ethical approval for this study was obtained from the Victoria University Human Research Ethics Committee on 19 December 2018 (approval number HRE18-195). All subjects provided written informed consent before data collection.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors have no competing interests to declare.

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Not applicable.

Authors' contributions

EA: conceived and conducted study; data collection, analysis and interpretation, drafting the manuscript. AH, DS: study concept and contribution to data interpretation; JPR, CAG, JM: contributed to data collection; HMC: contributed to data interpretation; SD: contributed to study concept. All authors contributed to a critical revision of the manuscript and approved its final version.

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